

CLAIMS

1. A motor vehicle steering system selectively operable in a steer-by-wire mode with rear steering, steer-by-wire mode without rear steering, electronic power assist steering (EPAS) mode with rear steering, electronic power steering (EPAS) without rear steering, mechanical backup manual mode with rear steering, and mechanical backup manual mode without rear steering, the steering system comprising:

a front road wheel actuator system including a front road wheel actuator adapted for directing an at least one front road wheel in accordance with a front steering value;

a rear road wheel actuator system including an independent rear road wheel actuator adapted for directing an at least one rear road wheel in accordance with a rear steering value;

a driver interface system including a reaction torque generator, the driver interface system coupled to the front road wheel actuator system, the driver interface system adapted to determine the steering value, and further adapted to communicate the steering value to the front and rear road wheel actuator systems;

a clutch mechanism selectively coupling the driver interface system and the front road wheel actuator system; and

a controller adapted to determine one of the steer-by-wire mode with rear steering, steer-by-wire mode without rear steering, electronic power assist steering (EPAS) mode with rear steering, electronic power steering (EPAS) without rear steering, mechanical backup manual mode with rear steering, or mechanical backup manual mode without rear steering, the controller coupled to the front and rear road wheel actuator systems, the driver interface system, and the clutch mechanism,

wherein in the steer-by-wire mode with rear steering the controller maintains the clutch mechanism in a disengaged state and the controller operates the driver interface system and the front and rear road wheel actuator system such that the motor vehicle is electronically steerable; and in the steer-by-wire mode without rear steering the controller maintains the clutch mechanism in a disengaged state and the controller operates the driver interface system and the front road wheel actuator system such that the motor vehicle is electronically steerable; and in the EPAS mode with rear steering the controller causes the clutch mechanism to engage and selectively causes one of the road wheel actuator system or the driver interface system to provide electronic power assist steering while controlling the rear steering; and in the EPAS mode without rear steering the controller causes the clutch mechanism to engage and selectively causes one of the road wheel actuator system or the driver interface system to provide electronic power assist steering while deactivating the rear steering; and in the backup mode with rear steering, the controller causes the clutch mechanism to engage such that the motor vehicle is mechanically steerable while controlling the rear steering; and in the manual backup mode without rear steering, the controller causes the clutch mechanism to engage such that the motor vehicle is mechanically steerable while deactivating the rear steering .

2. The steering system of claim 1 wherein the driver interface system includes at least one angular position sensor to determine an angular position of a steerable member, a reaction torque generator current sensor, and a reaction torque generator temperature sensor.

3. The steering system of claim 1 wherein the front road wheel actuator system further comprises at least one front road wheel position sensor, a front road wheel actuator current sensor, a front road wheel actuator temperature sensor, and a rack load sensor.

4. The steering system of claim 1 wherein the rear road wheel actuator system further comprises left and right rear road wheel position sensor, left and right rear road wheel actuator current sensor, and left and right rear road wheel actuator temperature sensor.

5. The steering system of claim 1 wherein the controller is further adapted to receive a set input signals indicative of at least a vehicle speed value, a lateral acceleration value, a yaw rate value, and an ignition mode.

6. The steering system of claim 1 wherein in the EPAS mode with rear steering, the controller controls one of the reaction torque generator or the front road wheel actuator to generate an assistive torque on the steerable member, and further wherein the controller controls the rear road wheel actuator to provide rear steering assist.

7. The steering system of claim 1 wherein in the EPAS mode without rear steering, the controller controls one of the reaction torque generator or the front road wheel actuator to generate an assistive torque on the steerable member, and further wherein the controller deactivates the rear road wheel actuator.

8. The steering system of claim 1 wherein in response to a driver interface system malfunction, the controller deactivates the reaction torque generator, and further wherein the controller controls the front road wheel actuator to provide electronic steering power assist and further wherein the controller controls the rear road wheel actuator to provide rear steering assist.

9. The steering system of claim 8 wherein the driver interface system malfunction includes at least one selected from the group of a reaction torque generator malfunction, an angular position sensor malfunction, a reaction torque generator current sensor malfunction, or a reaction torque generator temperature sensor malfunction.

10. The steering system of claim 8 wherein the driver interface system malfunction includes a reaction torque generator malfunction.

11. The steering system of claim 8 wherein the driver interface system malfunction includes an angular position sensor malfunction.

12. The steering system of claim 8 wherein the driver interface system malfunction includes a reaction torque generator current sensor malfunction.

13. The steering system of claim 8 wherein the driver interface system malfunction includes a reaction torque generator temperature sensor malfunction.

14. The steering system of claim 1 wherein in response to a front road wheel actuator system malfunction, the controller deactivates the front road wheel actuator, and further wherein the controller controls the reaction torque generator to provide electronic steering power assist and further wherein the controller controls the rear road wheel actuators to provide rear steering assist.

15. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes at least one selected from the group of a front road wheel actuator malfunction, a front road wheel position sensor malfunction, a front road wheel actuator current sensor malfunction, a front road wheel actuator temperature sensor malfunction, or a rack load sensor malfunction.

16. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes a front road wheel actuator malfunction.

17. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes a front road wheel position sensor malfunction.

18. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes a front road wheel actuator current sensor malfunction.

19. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes a front road wheel actuator temperature sensor malfunction.

20. The steering system of claim 14 wherein the front road wheel actuator system malfunction includes a rack load sensor malfunction.

21. The steering system of claim 1 wherein in response to a rear road wheel actuator system malfunction, the controller deactivates the rear road wheel actuator, and further wherein the controller maintains the control of the steering system in steer-by-wire mode without rear steering.

22. The steering system of claim 21 wherein the rear road wheel actuator system malfunction includes at least one of a rear road wheel actuator malfunction, a rear road wheel position sensor malfunction, a rear road wheel actuator current sensor malfunction, or a rear road wheel actuator temperature sensor malfunction.

23. The steering system of claim 21 wherein the rear road wheel actuator system malfunction includes a rear road wheel actuator malfunction.

24. The steering system of claim 21 wherein the rear road wheel actuator system malfunction includes a rear road wheel position sensor malfunction.

25. The steering system of claim 21 wherein the rear road wheel actuator system malfunction includes a rear road wheel actuator current sensor malfunction.

26. The steering system of claim 21 wherein the rear road wheel actuator system malfunction includes a rear road wheel actuator temperature sensor malfunction.

27. The steering system of claim 1 wherein in response to a driver interface system malfunction and a front road wheel actuator system malfunction, the controller deactivates the reaction torque generator and the front road wheel actuator and further wherein the controller controls the rear road wheel actuators to provide rear steering assist.

28. The steering system of claim 27 wherein in response to a driver interface system malfunction and a front road wheel actuator system malfunction, the controller causes the clutch mechanism to be engaged such that the motor vehicle is manually steerable with rear steering assist.

29. The steering system of claim 1 wherein in response to a driver interface system malfunction and rear road wheel actuator system malfunction, the controller deactivates the reaction torque generator and the rear road wheel actuator and further wherein the controller controls the front road wheel actuators to provide electronic steering assist.

30. The steering system of claim 29 wherein in response to a driver interface system malfunction and rear road wheel actuator system malfunction, the controller causes the clutch mechanism to be engaged such that the motor vehicle is electronically steerable with front steering assist.

31. The steering system of claim 1 wherein in response to a front and rear road wheel actuator system malfunction, the controller deactivates the front and rear road wheel actuators and further wherein the controller controls the reaction torque generator to provide electronic steering assist.

32. The steering system of claim 31 wherein in response to a front and rear road wheel actuator system malfunction, the controller causes the clutch mechanism to be engaged such that the motor vehicle is electronically steerable with reaction torque generator steering assist.

33. The steering system of claim 1 wherein in response to a driver interface system malfunction, and front and rear road wheel actuator system malfunction, the controller deactivates the reaction torque generator and front and rear road wheel actuators.

34. The steering system of claim 33 wherein in response to a driver interface system malfunction, and front and rear road wheel actuator system malfunction, the controller causes the clutch mechanism to be engaged such that the motor vehicle is manually steerable.

35. The steering system of claim 1 further comprising a battery to provide electrical current to the driver interface system, front road wheel actuator system and the rear road wheel actuator system, and further comprising a battery current sensor coupled to the controller, the battery current sensor sensitive to fluctuations in battery current.

36. The steering system of claim 35 wherein in response to a threshold battery current value, the controller deactivates the reaction torque generator, the front road wheel actuator and the rear road wheel actuator, and further wherein the controller causes the clutch mechanism to be engaged such that the motor vehicle is manually steerable.

37. The steering system of claim 35 wherein in response to no electrical current to the driver interface system, front road wheel actuator system and the rear road wheel actuator system, the clutch mechanism is engaged such that the motor vehicle is manually steerable.

38. The steering system of claim 1 wherein the front road wheel actuator is coupled to a pinion, and further wherein the front road wheel actuator is adapted to rotate the pinion such that the pinion causes a rack to move along a transverse axis of the motor vehicle.

39. The steering system of claim 1 wherein the reaction torque generator is coupled to a steerable member, and further wherein the reaction torque generator is adapted to rotate a shaft such that the shaft causes the steerable member to rotate.

40. The steering system of claim 1 wherein the reaction torque generator is further adapted to generate reaction torque in the steer-by-wire mode, and further wherein the reaction torque generator is adapted to generate electronic power assisted steering in the EPAS mode.